Postrum II: A Posture Aid for Trumpet Players

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Abstract

While brass pedagogy has traditionally focussed on sound output, the importance of bodily posture to both short-term performance and longer-term injury prevention is now widely recognized. Postrum II is a Linux-based system for trumpet players that performs real-time analysis of posture and uses a combination of visual and haptic feedback to try to correct any posture issues that are found. Issues underpinning the design of the system are discussed, the transition from Mac OS X to Ubuntu detailed, and some possibilities for future work suggested.

Keywords

Brass pedagogy, posture, calm technology, Pd-extended, Ubuntu.

1 Introduction

Wright [1] notes that while brass instrument playing involves the combination and coordination of multiple facets, tone production is relatively poorly understood and often considered dauntingly complex. Perhaps as a result of these difficulties, trumpet pedagogy has traditionally focused on sound production with little consideration of the body. As a result, the role of the body of the player tended either to go unrecognized, or the ability of the body to intuitively find appropriate techniques has been assumed [2].

Over time this lack of concerted engagement with the body has proved problematic; there has been increasing recognition that bodily posture is important, not only in terms of sound production and performance, but also longer-term injury prevention. For example, Kelly [3], Whitener [2] and Dornbusch [4] note that poor posture can degrade respiratory function, stamina, embouchure and tone. Others have suggested that poor posture in trumpet players can lead to back, shoulder and neck pain [5] [6], and muscular weakness [4]. Indeed, similar problems have been identified in other musicians, from pianists to string players, and a number of clinics established specifically to deal with musicians' injuries [7].

As a result, the literature of brass pedagogy has sought to identify the typical posture problems found in trumpet players and arrived at a consensus regarding ideal alignment of the body. Based on this literature, we introduce a posture aid that analyzes the posture of a standing or seated player in real-time and, if necessary, applies corrective haptic and visual feedback. In particular, we describe how this system builds on previous work that utilized haptic feedback only, and our transition from Mac OS X to Ubuntu Linux.

2 Optimal Posture

Drawing on the literature of brass pedagogy described above, three distinct types of posture issue can be identified (see Figure 1).

Figure 1: Optimal posture (far left) compared to three common types of posture issue.

Within the figure above, the first image (from left to right) demonstrates optimal posture

allowing the lungs and ribcage freedom to operate. The second image shows the head rotated forward, thereby restricting the flow of air out from the neck and back of throat. The third image shows both the head rotated forward and the sternum collapsed, inhibiting respiration. Finally, the fourth shows excessive sideways twisting of the body [8].

Of course, not all trumpet players stand; some adopt a seated playing position. However, the posture issues experienced are closely related and pragmatically almost identical to those that occur while standing. Indeed, Jacobs [1] has referred to a position that he termed “standing while sitting” that would provide the best position for the lungs to function and support the tone of the instrument.

3 System Design

3.1 Previous System and its Discontents

Our previous prototype consisted of a Microsoft Kinect 3-D camera and Synapse application for posture analysis, a mapping layer created in the MaxMSP visual programming environment, and two 2x2 vibrotactile arrays built around Arduino microcontrollers [8]. The combination of Kinect camera, Synapse application and MaxMSP required that the system run on Mac OS X (specifically, Mac OS 10.9 on a Macbook Pro). However, the expense of these underlying technologies limited the potential to build multiple instances of the system. This is desirable as it makes it possible to test the system on several users simultaneously, or in different locations at the same time.

3.2 Transition to Ubuntu

The new system supplements simplified haptic feedback with visual feedback via an ambient projection. It also adds the ability to capture time-stamped audio for subsequent analysis. Thus, it becomes possible to compare posture to sound output over time. However, perhaps most significant change, at least in terms of implementation, is the move from Mac OS to Ubuntu Linux.

Some elements of this transition are reasonably straightforward. For instance, the Open Source and cross-platform Pure Data-extended (Pd-extended) provides a near like-for-like replacement for the MaxMSP. Both are derived from the Max family of languages developed at IRCAM in Paris and offer similar functionality, to the point that they even share many object names [9].

3.3 System Overview

The Postrum II system consists of three layers:

- input (camera and audio)
- analysis and mapping
- output (visual and haptic feedback)

3.3.1 Input

A generic USB webcam is initialized as a video4linux (V4L) device. The [pix_video] object then is used to grab live video from the V4L device at a resolution of 640x480 pixels and 30 frames per second (FPS). CD-quality mono audio is also collected from a microphone via the [adc~] object, timestamped, and recorded to disk using the [writesf~] object. As explained in the future work section of this paper, this data is not yet fully utilized, but has rich potential.

3.3.2 Analysis and Mapping

The analysis and mapping layer sits between the input and output layers and is primarily built in Pd-extended. Each frame of video is passed into a real-time analysis sub-patch that implements a combination of computer vision processes. Firstly, background subtraction is used to capture a player-specific reference image of optimal posture and isolate the player from her surroundings. Next, the [pix_movement] object creates a black and white bitmap of the difference between an average of the most recent frame and the reference image (an average of several frames can be used if smoothing is required). The difference between the two highlights areas of the body that have departed from the optimal posture, and from there the type of posture issue is identified (based on the types detailed above), as well as the degree of deviation from the ideal.

This posture data is converted and then dispatched as Open Sound Control (OSC) messages to the feedback layer. The figure below (Figure 2) outlines the data flow through the Postrum II system, showing its three distinct layers.

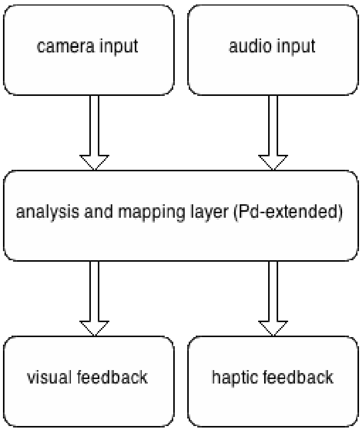

Figure 2: Flow diagram of the main elements of the Postrum II system

3.3.3 Output

The concept of calm technology was developed by Weiser and Brown [11]. It concerns the shifting of interaction to the periphery of attention in an attempt to reduce information overload. Informed by this concept, in this research, an ambient visual display is used to indicate departures from the optimal posture. When departures from the ideal are minor or short-lived, the aim is to inform but not significantly distract the player from other musical tasks by occupying only the periphery of their attention (see Figure 3). In particular, a key design principle is that the visual feedback should be sympathetic to sight reading; that it should not require the eyes to be taken off a musical score in order for it to be processed by the player.

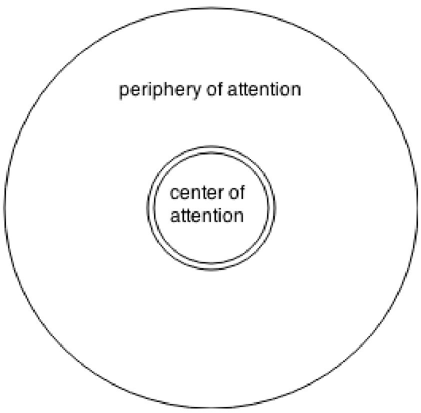

Figure 3: Principle of the visual feedback.

The position and color of the projection around the periphery indicate the type of posture issue and its severity. The ambient display is split into five areas (see Figure 3). Colors range from green (optimal posture) through to red (severe posture issue). When the entire display is green the player's posture is optimal. The area directly above the head (A) turning red indicates that the head has rotated forward; the areas below this (B) turning red denotes that the sternum has collapsed; the left or right sides of the display (C) turning red indicates that the body is twisted to one side or the other. If optimal posture is not resumed within a few seconds, a second state is entered. In this state, visual feedback remains but is progressively supplemented by haptic feedback to more concertedly attract the attention of the user. The amplitude of the haptic feedback is proportional to the extent and duration of the postural deviation.

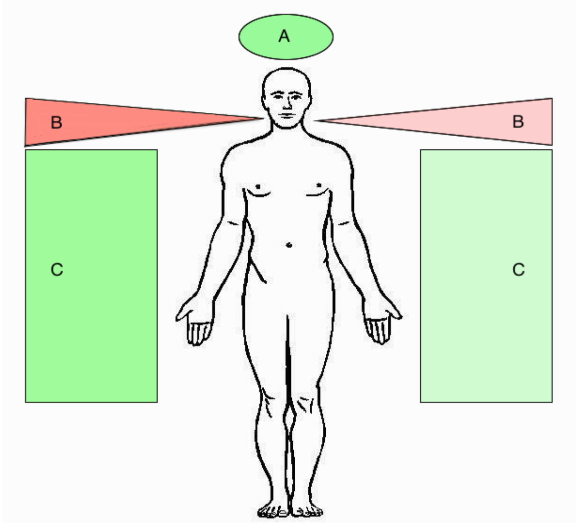

Figure 4: Visual feedback in Postrum II.

The visual feedback component is implemented in the open source Processing programming language. It is displayed on a large television screen or, preferably, projection onto the wall of the practice room. Compared to the first Postrum system, the haptic feedback component is greatly simplified. It consists of a single 2.5cm vibration motor mounted on the torso (just above the waist) using a soft and elastic band. It is controlled by an Arduino microcontroller via a simple H-bridge. The Arduino in turn connects to the host computer via a wired USB connection. The amplitude of the vibration motor is able to be continuously varied by means of pulse-width modulation.

3.4 Related Work

Our earlier system aside [8], to the best of our knowledge, previous posture aids aimed specifically at brass players have been passive mechanical devices only. The *Shulman System for Brass* [13] rests on the sternum and holds the trumpet in an optimal position in front of the player. The *ERGObrass* [14] supports the weight

of the instrument on a rod attached to the floor or to the player's belt, thereby freeing up the arms, shoulders, and upper body.

Work more similar to ours exists in other musical domains. For instance, the *Music Jacket* [15] is a wearable, real-time system for novice violin players that uses a camera to track the position of the bowing arm and haptic feedback to "nudge" the player into adopting good posture habits. The *Integrated Vibrotactiles* interface [16] is also aimed at violinists. In a similar manner to the Music Jacket, it provides the player with real-time haptic feedback that aims to foster good movement and posture within a 3-D space.

4 Discussion and Future Work

The Postrum II solves some of the design issues identified in our first prototype. In particular, it attempts to reduce the cognitive demands placed on the player when only minor postural deviations are identified, and thus impinge less on the ability to carry out attention-heavy musical tasks.

At present, Postrum II uses a standard Ubuntu distribution. It would be interesting to compare its performance and ease of use to that of a specialized audiovisual variant. It would also be a relatively small step from our current system to one that is able to run on the Raspberry Pi single board computer (SBC). This would not only further reduce the cost of the system, but enable the technology to "disappear" into, or be hidden inside, the fabric of the practice room.

A particularly interesting possibility for future work lies in comparing posture data and the (recorded) sound output of the instrument to look for correlation between the two. Another possibility concerns studying the effects of tiredness and fatigue on the posture of expert trumpet players. While these players may usually initially present with good posture, the effect of long (and potentially tiring) practice sessions has so far been little explored.

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